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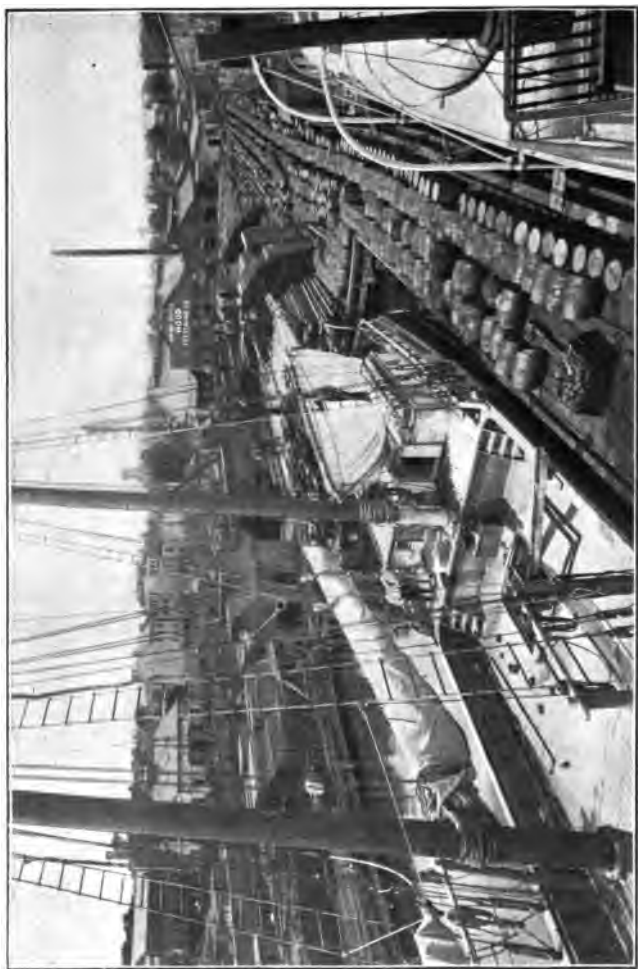


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MODERN WOOD PAVEMENTS

CREO-RESINATE PROCESS

INCLUDING A PAPER ON
RECENT EXPERIENCES WITH WOOD PAVEMENTS

By B. T. WHEELER

SUPT. OF STREETS OF THE CITY OF BOSTON

BY

FREDERIC A. KUMMER, C.E.

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THE CREO-RESINATE PROCESS

WHAT IT IS, AND WHEREIN IT IS SUPERIOR TO OTHER METHODS FOR THE TREATMENT OF TIMBER

The creo-resinate process is an improvement on the well known creosoting process. The improvement consists in the use, first: of dry heat instead of steam in the preliminary treatment, thereby securing complete sterilization of the timber to its heart, and killing all germs of decay. This absolutely prevents dry rot. Second, in the use, along with the creosote oil, of a considerable percentage of melted rosin, which solidifies on cooling, sealing up all the pores and making the wood water proof, much harder and more durable, much tougher and more elastic, and better able to resist decay because the creosote oil cannot be evaporated or washed out, and is thereby retained in the wood in its full strength and efficiency. This washing out or evaporation of the oil is one of the greatest weaknesses of the ordinary creosoting process.

Rectangular wooden blocks, of heart Georgia or long leaf yellow pine, treated by this process, form the best paving material known, for either light or heavy travel. Statistics from abroad as shown later on give a life for wooden pavements properly treated far superior to the life of asphalt, and in many instances equal to that of granite, and in addition there is secured the complete noiselessness of the pavement, an advantage of the greatest importance, high sanitary properties, owing both to the completely water proof nature of the treatment

and the highly antiseptic nature of the compound, decreased slipperiness, ease of traction, ease of cleaning, and of repair, and the maximum of life in service owing to the greatly increased elasticity, toughness and durability of the timber. On grades the pavement, with the blocks grooved as shown later on, constitute practically the only smooth, durable pavement which is not slippery.

The noiselessness of wooden pavements is not only of immense importance in promoting the comfort and health of persons on residence streets, but has a direct money value on business thoroughfares, where, especially in summer when windows are open, the noise from traffic over granite, asphalt or brick is often so great as seriously to interfere with business. Higher rentals could be secured with noiseless pavements. Further, every street surrounding public buildings, hospitals, churches and public libraries should be paved with wood on account of its noiseless qualities.

Wood pavements, of properly selected timber, thoroughly treated, and well laid, are not cheap pavements in any sense of the word, but they are the best pavements in the world, a fact long acknowledged abroad. The experience of most of our cities is showing that in the long run the best pavement is the cheapest. Poor pavements of any kind, composed of cheap materials, and laid in a slipshod manner, although apparently an economy in first cost, prove very expensive in the long run, and even where such pavements are guaranteed, the result is a patch work, the contractors merely figuring on keeping the street in a passable condition under the broadest interpretation of the maintenance bond until the time limit expires and then turning over to the city a worthless pavement, requiring immediate renewal. In many instances the companies laying these pavements refuse to make any repairs whatever unless forced to do so by long and costly process of law. Even where repairs are promptly made and well carried out, the consequent interruption to traffic, and to the business and convenience of



INTERSECTION OF SCHOOL AND TREMONT STREETS, BOSTON, IN FRONT OF THE PARKER HOUSE.
CREO-RESINATE WOOD PAVEMENT LAID IN SUMMER OF 1900.

property holders, is an item having a large money value. A large number of our American cities are laying up a very great burden for themselves in the future, when the maintenance of apparently cheap pavements will prove a most unwelcome expense to the already heavily burdened taxpayer.

Modern wooden pavements are laid on a well constructed foundation of from 4 to 6 inches of concrete, depending on the traffic and the nature of the sub-grade. The blocks are three inches deep for light and moderate traffic, and four inches deep for the heaviest traffic. This gives a wearing surface from two to three times as deep as that of the ordinary asphalt pavements. The blocks are laid either on a thin sand cushion, spread on top of the foundation or directly on the concrete. Being laid as closely together as possible (except on grades), they require no filler between them—a light sweeping of fine hot sand being all that is necessary. If desired, however, a grouting of asphaltic cement, or creo-resinate mixture may be used along with the sand. Such a grouting along the curb line is desirable under any circumstances.

• Especial attention should be called to the peculiar adaptability of this form of pavement for the roadway of bridges. Its lightness, durability and smoothness give it an immense advantage over the usual pine planking used, and as it will have a life of many years, it soon shows its great economy over the necessary and expensive re-decking of bridges yearly or oftener as is frequently the case. The Harvard Bridge, Boston, 11,425 yards, was paved with creo-resinate blocks in 1901 for this reason.

The creo-resinate treatment, whether applied to paving blocks, railroad ties, trestle timbers, conduits, decking, dock timber, or any other class of work where decay is to be feared, and where hardening and toughening of the wood is desired, is the best treatment that can be applied to timber. The plant of the United States Wood Preserving Company has a capacity of twenty-five million feet B. M. of lumber per year, or in paving block over half a million square yards.

RECENT EXPERIENCE WITH WOOD PAVEMENTS

BOSTON WANTED NOISELESS PAVEMENTS—FAVORABLY IMPRESSED
WITH WOOD PAVEMENTS FROM SUCCESS IN EUROPE—
GOOD RESULTS FROM EXPERIMENT LAST YEAR—
LARGE CONTRACTS FOR WOOD THIS YEAR.

By B. T. WHEELER*

SUPERINTENDENT OF STREETS OF THE CITY OF BOSTON

The New England metropolis is a city of conservatism. Sprung from the Puritans, her people remain true to the traditions of their ancestors. Their progress has been a slow but steady one; and their development along lines of careful investigation. Cleaving to that which was good, they have not hurried to adopt new conditions until convinced by demonstration which appealed to their good judgment that an improvement would result. Oftentimes our good city has waited for some more daring municipality to make the experiment; but she has seldom failed to avail herself of these experiments when they appealed to her judgment, and has often wrought from the crude beginnings of others the finished product which they had not conceived.

GRANITE CONSIDERED A NECESSITY AT FIRST

Boston's business district is compressed into a comparatively small area with densely crowded thoroughfares, outside of and surrounding which is a large suburban district containing the homes of her workers. Until within very recent years

* Superintendent of Streets, Boston, who read this paper before the eighth annual meeting of the American Society of Municipal Improvement, held at Niagara Falls, N. Y., October 1 to 4, 1901.

her business section has been paved with granite blocks; her residential streets of macadam. Of the 491.85 miles* of public highways within the limits of the city 292 miles are still of macadam, and eighty-six of gravel. Within recent years there have been laid some areas of asphalt pavement—only 14.76 miles in all—in an attempt to give the residential district closely adjoining the business section a permanent pavement which would bear the travel imposed upon it, without the noise of granite blocks or the dirtiness of macadam. Asphalt pavement has, however, never appealed strongly to the popular mind. Those who use the streets protest against it in the business sections and it is not desired by the pleasure-driving public in the suburban districts.

NOISELESS PAVEMENT DEMANDED

The problem of the Street Department has been for some years to provide a pavement which should be more noiseless than granite blocks, less slippery than, and as durable as, asphalt, and more permanent as to its wearing surface. During a previous incumbency of the office of superintendent of streets, six years ago, this problem was forced home to me. The Back Bay district of the city, so called, was densely populated with the homes of the wealthy class. Only a few years previous these citizens, protesting against the laying of an asphalt pavement in a boulevard known as Commonwealth avenue, had raised a fund, with the interest from which they are paying for a portion of the repairs of the macadam surface which was laid at their request. In 1895 a body of these citizens, upon another street in this district, had protested against an asphalt pavement, preferring macadam, and their desires were gratified; but, during the five years since, a change has come to many of these. The popular mind is not more inclined toward asphalt, and still complains of its slipperiness; but it is less inclined to endure the dust which dry weather, and the mud which wet weather produces upon a macadam surface, and

* Mileages given are of February 1, 1901.



HOVLSTON STREET, BOSTON, LOOKING TOWARD TREMONT STREET. PAVED WITH CREO-RESINATE GROOVED BLOCK, THEREBY PROVIDING JOINTS TO GIVE INCREASED FOOTHOLD ON A GRADE.

granite-block pavement, even, is sometimes asked for in preference to either.

FAVORABLY LOCATED TO GRANITE SUPPLY

This city is particularly fortunate, because of its location, in the character of the granite-block pavements which it lays. Surrounded by some of the finest granite-block quarries of the world, she is enabled to obtain the best and smoothest blocks which nature helps to produce. These are laid, in recent years, upon a six-inch American cement concrete base, with a two-inch sand-bed, and the joints are filled with either road pitch and pebbles, or, during my control of her streets, with Portland cement grout. I believe to-day that Boston has the smoothest granite-block pavements in this country, if not in the world; but such pavement, while withstanding the wear of traffic, and of time, is not fitted for the ear of tired human nature. Macadam has not permanency, is expensive to maintain in good repair, is unsanitary and disagreeable under the varying conditions of climate. Asphalt, to which large numbers of the cities of this country turn as an expedient and satisfactory pavement for residential and lightly traveled streets, does not fully meet the requirements of our city. Situated on the sea, and traversed by its estuaries, with widely varying temperature during all seasons, her climate is one for which asphalt seems less adapted than for that of any other large city of this country, because of the condensation of vapor which these climatic changes cause. Whether this moisture upon the surface remains fluid or is frozen by the morning chill, almost equal slipperiness is produced; and it is necessary, during a surprisingly large number of mornings of the year, to sand completely all well-traveled asphalt streets where laid upon the slightest grade—and Boston, built upon the rugged contours of Massachusetts, having in her business section the three hills which first caught the eye of the voyager of the fifteenth century, has very little area of level street surface.

Until last year, when I again assumed control of the Street Department, no forms of pavement had been attempted



BEACON STREET, NEAR MASSACHUSETTS AVENUE, BOSTON. CREO-RESINATE WOOD PAVEMENT COMPLETED
IN SEPTEMBER, 1901.

besides those mentioned, except unsatisfactory experiments with brick and coal-tar concrete. Neither brick nor coal-tar products can withstand the traffic of even our densely populated suburban districts.

In an attempt to solve the problem thus presented, some experiments have recently been made in the laying of wooden pavements, after noting the results achieved in the few sections of this country in which they have been laid.

WOODEN BLOCK A SUCCESS IN EUROPE

Treated wooden block paving has been used in London for over thirty years on both her finest and most heavily trafficked roadways. Paris has nearly four times as many square yards of it in use as of asphalt. There had been laid in 1891 484,000 square metres, and in 1898 1,165,000 square metres of wooden blocks, there being at that time 382,600 square metres of asphalt, and 1,348,000 square metres of macadam.

Foreign growths of wood are, however, practically prohibited for use in this country by reason of their large cost. To produce a pavement at moderate and justifiable expense, a native wood must be used, so treated, if possible, as to harden its fiber, make it practically impervious to moisture, and not readily susceptible to the varying conditions of heat and cold. There is no gauge of durability by which the attempts to produce such results can now be judged. Practice has not yet demonstrated in this country what our natural products can create in the way of a permanent pavement of this character.

ITS INTRODUCTION IN BOSTON

There were laid last year in this city, for experimental purposes, in the midst of the otherwise asphalted surface of a busy, but lightly trafficked, thoroughfare, two small areas of wooden blocks, 1,360 square yards in all, treated by the so-called "creo-resinate" process. These areas were laid in the steepest grades thereof, and in one case for only half the width of the street, the other half being of asphalt, that the relative merits of the two might be compared.

This pavement was prepared and laid in the following manner:

The blocks were uniformly four inches wide, four inches deep and eight inches long, of long leaf Georgia yellow pine, free from sap, loose or rotten knots, and with no second-growth timber allowed. These blocks were placed in an air-tight cylinder, and the dry heat was raised to 215 degrees Fahrenheit, without pressure, for one hour, for the purpose of expelling the moisture. The heat was then increased, pressure was applied, and the degree of both was raised gradually, in order to avoid injury to the fiber, during a period of two hours, until the heat had reached 285 degrees, and the pressure about ninety pounds, and both were then held at that point for one hour. The heat was then shut off, and the tanks allowed to cool gradually for one hour. At the end of this time the heat had been reduced to 250 degrees, and the pressure to about forty pounds. The pressure was then blown off and the heat still further reduced. Vacuum was then applied until about twenty-six inches was reached; and, while under vacuum, the creo-resinate mixture was run into the cylinders at a temperature of from 175 to 200 degrees and hydraulic pressure was then applied, reaching 200 pounds per square inch, and kept at this point until from twenty-one to twenty-two pounds of the mixture per cubic foot had been absorbed. The liquid was then run off, and the wood placed in another cylinder, and milk of lime at a temperature of 150 degrees was run in, and hydraulic pressure of about 200 pounds was applied for one hour.

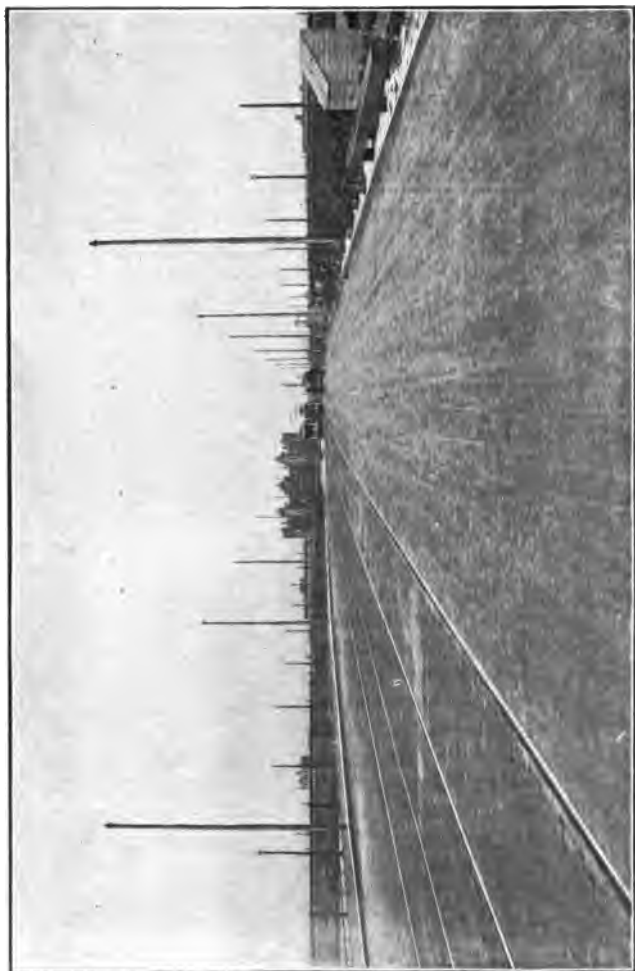
The blocks were laid with the grain vertical upon a foundation consisting of American cement concrete, six inches in depth, with a one-inch cushion of clean, screened sand, and were driven tightly together at every sixth row. The joints were then filled with dry, screened sand, and the pavement rolled with a five-ton steam roller until the blocks presented a firm, uniform and unyielding surface. The joints were then filled with a creo-resinate mixture or road pitch, heated to 300

degrees Fahrenheit, and the whole covered temporarily with one-quarter inch dressing of clean, screened, sharp sand.

THE RESULTS PROVE SATISFACTORY

It is apparent, after a year's experience with this pavement, that it is satisfactory as so laid in every respect, except with regard to slipperiness, and that, as so laid, an almost absolutely noiseless pavement was obtained, the surface of which, under use, became so unified that the joints were indistinguishable, and the pavement consequently slippery. No wear has yet been apparent. The surface remains perfect, and in comparison with the asphalt adjoining it, it is preferable in all respects except that of slipperiness, in which, practically, it does not differ; and, upon the grade of 4 per cent. at which it was laid, it has nothing to recommend it in this respect.

I have this year laid an area of 7,940 square yards upon a level street, in the same manner as above described, which I believe will be eminently satisfactory in every respect, and am about to lay this fall another area of 6,640 square yards upon a nearly level street, where I expect the same results; but the problem of noiseless, non-slippery and permanent pavement which can be laid upon grades exceeding 2 per cent. has not yet been satisfactorily solved. With the hope of more satisfactory results in this respect, however I have laid upon a 3 per cent. grade an area of 2,000 square yards of wooden blocks, so recently put down as not to permit me to make any statement of the results obtained. This was laid from blocks prepared as above mentioned, differing only in shape and in the character of the joint. From each block, four by four by eight inches, there was removed from one side at the top a section one-quarter inch in thickness for the length of the block, and one and one-half inches in depth. When these blocks were laid as above described, and driven closely, there was a quarter of an inch opening, or joint, remaining, extending clear across the street with each width of block, one-quarter of an inch wide, and one and one-half inches in depth. These joints were



**HARVARD BRIDGE, BOSTON, MASS., CONNECTING BOSTON AND CAMBRIDGE. 11,425 SQUARE YARDS,
LAID WITH CREO-RESINATE WOOD BLOCK IN FALL OF 1901.**

filled with Portland cement grout concrete. It is my expectation that this material upon the surface of the street every four inches will remove the slippery conditions which would otherwise exist, and furnish better foothold for horses.*

LARGE AMOUNT LAID THIS YEAR

There is in my charge, as commissioner having the care—with a representative of the adjoining city of Cambridge—of those bridges crossing the Charles River and connecting the two municipalities, a bridge called Harvard Bridge, having a roadway area of 11,425 square yards. This bridge was built in 1891 within an insufficient appropriation, and in a manner which has proved to be a falsely economical one. In order to diminish the cost the structure was lightened and designed only to carry a wooden floor of four-inch deck and two-inch sheathing. Traffic upon this bridge has rapidly increased, and it has been necessary for some years to resheathe it annually; and it has now become apparent that two resheatings each year will only suffice. As the deck of the structure now shows signs of decay, it has been decided to redeck this entire structure with a hard pine deck, treated by the same creo-resinate process as are the blocks, and directly upon this the wooden-block pavement will be laid, closely driven and without joints; and a contract for this work is now being executed by the United States Wood Preserving Company of New York, which controls the creo-resinate process. What has for years had many of the characteristics of an uneven corduroy roadway, caused by the rapid wearing of the sheathing plank, will soon present an even, noiseless, smoothly riding surface, which will not subject the two cities to the cost of annual repairs. Wooden blocks have, therefore, filled a unique place in furnishing a

* In an interview published in the *Boston Globe*, November 13, 1901, Mr. Wheeler said: "The block paving on Boylston street from Tremont to Park square, which was laid in grout joint, with a quarter inch or so between the joints, has proved so far the most satisfactory piece of wood paving in the city. I do not think there has been any complaint of horses slipping on this section of the street."

permanent and satisfactory pavement, placed upon a structure which was not designed to carry the load of any other form of permanent pavement known.

HAS MANY ADVANTAGES.

I was brought to the execution of this work by the experience of the city of Chicago in laying a wooden pavement—treated, however, by another process—upon the Rush Street Bridge, which carried a large part of the freight traffic of an important railroad terminal, and which had required, therefore, many renewals annually of the wooden wearing surface of plank. This pavement had been laid over two years and a half, I think, when I last saw it, and was still apparently in first-class condition. Wooden pavement has therefore, it seems to me, a field peculiarly its own in replacing the plank surface of bridges in an economical and satisfactory manner.

The only question, aside from the desirability of laying such pavement upon steep grades, which I have already referred to, and which has not yet been satisfactorily demonstrated, is, then, one of durability, which time alone can determine; but the company which has laid this pavement has, for the protection of the city which I represent, given a good and sufficient guarantee to keep the same in condition satisfactory to the Superintendent of Streets for a period of ten years.

Wooden pavement has, then, these demonstrated advantages; it is noiseless; it remains where it is put—in other words, it does not creep or crawl, as in the case of asphalt wearing surfaces, becoming billowy under traffic; it can be taken up for necessary excavation—that *bête noir* of all street superintendents—and relaid handily, satisfactorily, and without large paraphernalia. These known qualities commend it; and I believe that the test of time will prove its durability and its superiority under moderate traffic and in residential sections over any other pavement now laid.

WOODEN PAVEMENTS AT HOME AND ABROAD

By F. A. KUMMER, C.E.*

No doubt we have all of us from time to time talked about pavements with others who have travelled abroad, even if we have not been there and seen them ourselves. The invariable question is: Why, if wooden pavements are so extensively and successfully used abroad, are they not used extensively in this country? Various reasons are assigned, difference in climate, difference in conditions of service, and what not; yet it has never been particularly evident that any of these reasons were good ones. Pavements, like everything else, are matters of vogue—of fashion. Wooden pavements are not in fashion in this country—that is all. Many people say wood has been tried in this country and failed. Has it? I cannot believe that any number of engineers believe this. There are between 800 and 900 miles of wooden pavements in this country, much of which is now being replaced with other forms of roadway. At one time there was a great deal more. What does this indicate, that wooden pavements have failed, or that sappy, unseasoned and untreated cedar or other blocks laid on earth, sand or planks have failed? The public is so very prone to generalize.

In this country wooden paving has had three distinct phases. To you gentlemen, this is not new. Many of you doubtless know the past history of wood more thoroughly than the writer because of personal experience with it, yet we may at least refer to what has been done. The first step was an improvement on the corduroy road. It converted a mudhole into a passable way. The round or hexagonal blocks were not treated, consequently they rotted. They were one-third sap wood, consequently they rounded quickly on the edges. They were highly unsanitary because they absorbed street filth. They sank into ruts and holes because they had no foundation; but

* From a paper read before the American Society of Municipal Improvements, at Niagara Falls, in October, 1901.



ROUND CEDAR BLOCKS, LAID ON SAND.

(From a pamphlet published in the interests of asphalt, entitled "What Shall the Pavement Be.") It is hardly necessary to point out that this is not a modern wood pavement.

they were cheap; they eliminated the mudhole, and in that way served a good purpose.

It occurred to some enterprising genius to improve this pavement by squaring the blocks and dipping them in tar. It seems unreasonable that this improvement alone should have suggested itself, so much room remained. However, great improvements do not come all at once. This form of pavement, generally known as the Nicholson block, was extensively laid in many cities—to their great and lasting sorrow. The taxpayer has not forgotten it, which is why wooden pavements are not fashionable. The public generalizes as always. Why anyone should have anticipated success with such a pavement is almost incomprehensible. In the first place, little or no care was taken in the selection of the timber; hard and soft, heart wood and sap, seasoned and unseasoned, all woods looked alike to the promoters of the pavement. A dipping in hot coal tar or pitch served to cover up the defects, and incidentally to seal up within the wood the moisture due to lack of seasoning, thus hastening dry or heart rot as much as possible. The introduction of laths between the blocks served to make large joints and thereby to admit as much water as possible under the pavement. Sometimes the pavements rolled in billows like the sea. At this stage they were generally thrown away. The use of untreated planks on earth as a foundation was ingenious in its insufficiency. That part of the pavement that was not heaved up by the frost went down by the rotting of the planks. Therefore it happens that the city father does not regard wood with favor.

As a third phase, creosoted wooden blocks on a proper concrete foundation have begun to be laid in a few places throughout the country. This is really a wooden pavement. The other was wood, but it was not a pavement. A block of well selected heart pine—preferably the long leaf Georgia pine—creosoted with not less than ten pounds of dead oil to the cubic foot, and laid on concrete with a thin sand cushion, if any, and watertight joints, will make a good and



ASPHALT—TREMONT STREET, BOSTON—WOOD
Paved in 1900, with Creo-Resinate Wooden Blocks on West Side, Asphalt on East Side

durable pavement, not slippery, not in the least noisy, sanitary because of its antiseptic treatment, durable, easy for horses and pleasant to drive over. It may not be the highest type of wooden pavement; the writer does not believe it is, but it is a good pavement, a far better pavement than the average brick or asphalt street, because it possesses none of the defects of either. It has been largely and very satisfactorily used in several Western and Southern cities, notably Indianapolis, Terre Haute, Galveston and New Orleans. In Indianapolis the experience of six years' service has been highly satisfactory, the pavement showing increased popularity over all other forms of roadway. Over 50,000 yards have been contracted for there this year alone (1901).

Briefly this constitutes about the history of the three stages of wooden pavements in this country. The pavements recently laid in Boston and other points in the East, constitute in the writer's opinion the beginning of a fourth stage, which will revive the interest in wooden pavements to such an extent that they will rapidly take the prominent place which they deserve—in the estimation of the taxpayers as well as of the city officials.

The history of wooden pavements abroad is a long one, and within the limits of this paper can only be briefly treated. The two most important cities abroad being London and Paris, perhaps we may as well confine ourselves to those points, although many other cities in England and on the continent, as well as in Australia, use wood in large quantities. In Germany, however, wood is not so popular as elsewhere on the continent. In Paris the wooden blocks are all manufactured and laid by the city authorities, the various plants having a capacity of 47,000 blocks per day, or about 1,000 square yards. The blocks are of two depths—15 c. m. (about six inches) for the softer varieties of wood, and 10 c. m. (about four inches) for the harder woods. The amount of wooden paving in that city is somewhat over one and a half million square yards. The woods used have about the following relative wear: (1)



LAYING CREO-RESINATE WOODEN BLOCKS ON BEACON STREET, BOSTON

Teak, (2) Karri, (3) Pitch Pine, (4) Native Pines. The latter are generally used. The traffic on the principal streets is enormous. On the Rue de Rivoli, it is over 65,000 teams per day or 3,400 per yard of width, and over 66,000 teams per day on the Avenue de l' Opera, or about 2,000 per yard of width. Fifth avenue, as counted for the Barber Asphalt Company some few years ago, showed 8,400 teams per day, and Madison avenue 7,000—about one-eighth of the Paris traffic. Under this traffic the native woods wear on the average 1 c. m., about one-third inch per year, and are allowed to wear down until 10 c. m. of the total depth of 15 c. m. have been worn off. They are then removed. This gives under the heaviest traffic in the world, with inferior woods, a life of ten years. The horses are not allowed to have calks on their shoes, which probably makes the wear a little less severe than in this country, but this is counterbalanced many times by the enormously greater volume of the traffic. On the other hand, the absence of the calks proves that the pavements are not slippery, an argument which is sometimes advanced against wood pavement. Some statistics as to slipping and falling on wooden pavements taken from the Report of the (London) Society for the Prevention of Accidents to Horses, and compiled from observations extending over thirty-two days, made by Col. Haywood, C. E., in charge of pavements and sewers of the city of London, show the following:

Total number of falls (including partial falls):

Asphalt.....	437
Wood	326
Granite.....	134

Number of complete falls:

Asphalt.....	190
Granite.....	130
Wood.....	39

Slipping to one knee only:

Asphalt.....	107
Wood.....	10

It may possibly be said that the wear above noted per year is considerable—although taken in connection with the volume of traffic this is not so. In Paris it is found that the rate of wear under the heaviest traffic, for wood, namely 1 c. m. per year, is about the same as the rate of wear for granite throughout the entire city.

In constructing the streets in Paris, the concrete is brought to a true surface by floating it with a grout composed of Portland cement and fine sand. No sand cushion is used. The blocks are laid directly on the smooth concrete surface and are laid perpendicular to the line of the curb. Laths, afterwards removed, are introduced between the blocks, making a joint of about three-eighths of an inch, which joint is grouted with sand and Portland cement. About twelve days suffices to complete any particular portion of a street—from the date of closing it to the date of opening it again to traffic.

Owing to the fact that soft woods are generally used in Paris, the surface of the wood is to some extent spongy, and the practice of spreading a thin layer of sand and fine gravel over the streets every few days is followed, the gravel being crushed and ground into the fibre of the wood, giving the roadway a sandy surface. This, of course, reduces the slipperiness of the pavement. In London, however, this is not so frequently done, and the figures for slipping given above are from London and not Paris streets.

Labor employed by the Paris city authorities costs from 80 to 90 cents per day, and the completed pavements cost for wood about \$3.10, for granite about \$3.40, and for asphalt about \$3.12 per square yard.

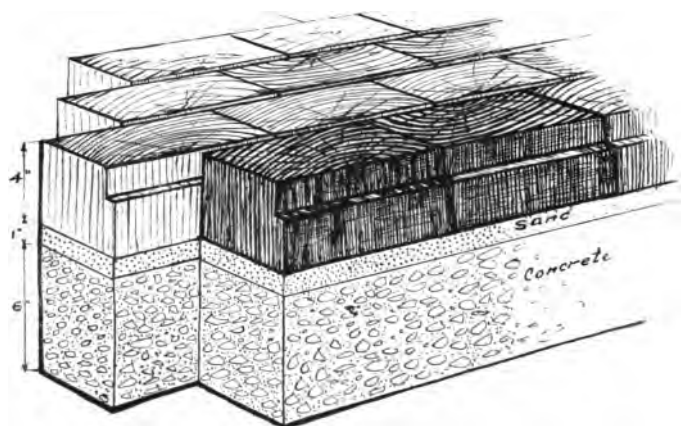
A large proportion of the woods used in Paris are treated, creosote being generally employed, but a large quantity of the preservative is not used—generally from eight to ten pounds per cubic foot.

In London there was laid from 1874 to 1884 about one million square yards of wood. There is now about four times as much in that city. The earlier pavements were untreated wood, gen-

erally Swedish deal, a wood of fairly good quality. Later it was "pickled" as they call it, by dipping in hot creosote oil after *thorough seasoning*. About ten years ago the Australian woods, Karri and Jarrah, came into favor—but are not now generally regarded as being as satisfactory as creosoted deal, and pavements laid with them are being taken up and replaced with creosoted Swedish deal. Most of the pavements now being laid consist of Swedish deal on concrete, either creosoted under pressure, or dipped, although untreated wood is used in some sections. The Swedish deal used in London weighs from 3,500 to 3,600 lbs. per thousand feet B. M., while our best long leaf Georgia pine weighs about 900 or 1,000 lbs. more per thousand feet, or 4,500 lbs. per thousand feet. It is therefore a much harder and more durable wood, having a crushing resistance along the line of the grain greater than that of oak.

Wood on concrete has been used for paving in London for some 27 years, its use having been begun about 1874, although the first London wooden pavements were laid in 1839. The average life of course depends upon the nature and volume of the traffic. In the Kensington District, where they use principally creosoted Swedish yellow deal, the average life of the pavements throughout the district is shown by the following extract from the 44th annual report of the Surveyor of the Parish of St. Mary Abbots, Kensington, for 1900:

"Kensington High street was paved with dipped blocks laid by the Improved Wood Paving Company in November, 1891, under their maintenance contract, which was then expiring. These dipped blocks had therefore lasted a little under eight years. The wood creosoted under pressure had lasted in the other roads about twelve years with the exception of the section of Kensington road marked (c), which had been down nine and one-half years. The wood was not worn out, but it had been very much cut up and damaged by the operation of the National Telephone Company, and as the consequent reparation would have involved the making good of a



GROOVED CREO-RESINATE, WOODEN BLOCK. BOYLSTON STREET, BOSTON

considerable portion of the entire area, it was deemed advisable to repave the whole surface and thus prevent the necessity of twice interfering with the traffic on this important road."

It should always be borne in mind that figures for wear are entirely relative. The traffic over the streets in London is very heavy, far heavier than on the streets of any of our largest cities, and the constant and very heavy omnibus traffic is particularly damaging to the pavements. Therefore the same class of street pavement in this country would, beyond question, have a much longer life. If, further, we can lay a class of timber naturally much harder and better able to resist wear than the Swedish deal, and add to this a treatment that will make the wood still harder, and completely waterproof, we should, under lighter traffic, at least succeed in obtaining double the life obtained on the heavily travelled streets of London or, say twenty-four years.

A section of long leaf Georgia pine, known abroad as pitch pine, 756 square yards in area, was laid with cement joints on Kings Road, London, some years ago, with the result that the average annual depth of wear during four and one-half years was only .055 of an inch. On the same road were laid sections of plain, and of creosoted deal, about the same time. The annual wear in the case of the plain deal averaged in depth during five years .139 of an inch, as against .055 of an inch for the pitch pine, or about two and one-half times as great. In the case of the creosoted deal on the same street, the average depth of wear was .111, or about twice that of the pitch pine. The results of the trial of pitch pine as summarized in a paper read before the Institute of Civil Engineers in 1883, were to the effect that "practically the plain pitch pine pavement is cheaper than yellow deal, and the ascertained vertical wear promises admirable results." The use of yellow pine, however, in London, in spite of this opinion, has not extended because of the great cost of the best qualities of lumber delivered there.

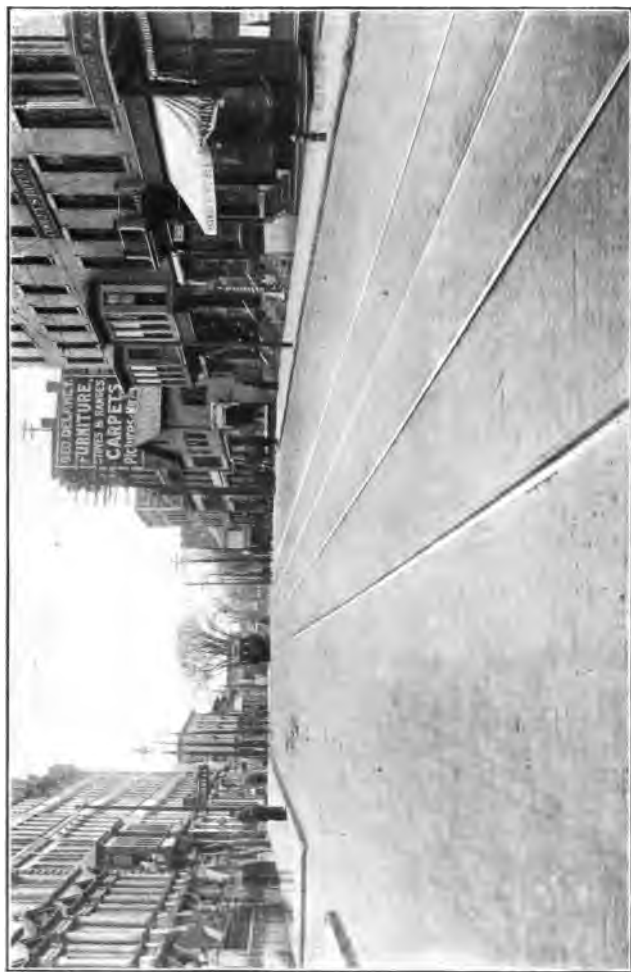
The dimensions of the blocks used in London are almost invariably 3" x 9" on the wearing surface, and 4" to 5" in depth. The blocks are often worn in some places to little more than an inch in depth before being removed. Such excessive wear would only be secured in the case of pitch pine, in a period approximately two and one-half times as great as that required for equal wear with the Swedish deal.

With regard to a guarantee for maintenance, the conditions of contract vary in every district. In some districts the authorities employ their own labor, and in such cases the timber merchant simply supplies the blocks under the inspection of the Surveyor of the district, and their liability ends with the delivery of the block. In other districts, where the work is contracted for in its entirety, the contractor has to supply and lay the wood paving to the satisfaction of the Surveyor, and his liability ends as soon as the work is completed. In other districts the practice is for the contractor to keep the roadway in perfect condition for a given period, varying from six months to three or more years, either free or at a price per year included in the original bid. Prices thus vary considerably. Throughout the district of Kensington, 43,476 square yards of pavement, laid during the year ending March, 1900, all creosoted deal, part 4" and part 5" in depth, cost an average price of about \$2.25 per square yard. This embraces no cost for maintenance. The Surveyor of the district in the report previously referred to, speaking of several streets paved late in the year with 4" creosoted deal blocks, says: "This reduced depth of wood has been adopted in pursuance of my recommendation embodied in the report of the Works Committee adopted by the vestry on the 30th of November, 1898."

The following table taken from the report of the district of Kensington above referred to shows the annual expense for maintenance per yard of total area, upon twenty-three streets. The heavy cost on the first street comes from destructive operations in the street by the Telephone Company in laying mains.

TABLE.

Road.	Date originally laid.	Total area of road, yds.	Area repaired, yds.	Cost per yd., total area, L. s. d.
Avondale Park	Nov., 1893	756 4-9	87 1-9	0 0 10-8
Beauchamp Place	Nov., 1888	1,876 2-9	1	0 0 0 1-38
Brompton Road	Dec., 1888	13,166 7-9	67 5-9	0 0 0 1-9
Church Street and Silver Street.....	Oct., 1885 Aug., 1877	8,556 1-9	184 7-9	0 0 0 29-64
Colville Road and Terrace.....	May, 1892	3,328 1-3	38 4-9	0 0 0 3-16
Earls Court Road.....	Oct., 1883	13,949 1-3	227 8-9	0 0 0 22-57
Eglin Crescent	June, 1883	6,886 5-9	145	0 0 0 5-14
Fulham Road	July, 1878	17,042 2-3	25 6-9	0 0 0 1-21
Gloucester Road	Oct., 1881	16,860 5-9	42 7-9	0 0 0 1-17
Palace Gate	Dec., 1881	7,102 2-9	144 8-9	0 0 0 1
High Street Notting Hill.....	Dec., 1878	18,846 2-3	368 8-9	0 0 0 7-12
Holland Park Avenue.....	Oct., 1882	1,714	39 1-9	0 0 0 4-5
Kensington High Street	May, 1887	2,321	114 4-9	0 0 0 5-8
Kensington Park Road	Aug., 1898	20,932	668 1-9	0 0 0 1
Kensington Road	Nov., 1880	6,885	159 4-9	0 0 0 4-9
Ladbroke Grove	Aug., 1896	10,327 8-9	181 2-9	0 0 0 3-8
Norfolk Terrace, Archer Street & Westbourne Grove	May, 1881	30,360 5-9	622 3-9	0 0 0 3-8
Old Brompton Road	May, 1882	6,541 6-9	109 4-9	0 0 0 10-23
Pembroke Villas	May, 1895	4,119 2-9	123 3-9	0 0 0 17-30
Portobello Road	Sept., 1894 Aug., 1883	9,221	14 4-9	0 0 0 1-44
Redcliffe Gardens	June, 1893	477 1-9	41 6-9	0 0 0 27-10
Richmond Road	Apr., 1891	3,509 4-9	117 3-9	0 0 0 15-16
Sydney Place	Nov., 1889	106	9	0 0 0 1 4-9
Tavistock Road Footbridge.....	Nov., 1893			



MAIN STREET, SPRINGFIELD, MASS. LAID WITH CREO-RESINATE WOOD BLOCKS IN SEPTEMBER, 1901

With reference to creosoted blocks, the report of Mr. Weaver, Surveyor, Kensington District, quoted above, says: "The superiority of creosoted blocks over plain wood is demonstrated by the fact that creosoted five-inch blocks in High street, Notting Hill, and Fulham road, lasted twelve years, whereas the previous paving consisting of six-inch plain deal blocks lasted less than nine years under much lighter traffic."

The renewals are made necessary generally by the traffic at the principal points of stoppage, for omnibusses for instance, where the continuous heavy pounding of the horses when starting necessarily wears the pavement away at that one spot more rapidly than at other parts of the street.

Wooden pavements abroad are often sprinkled with sand, as before mentioned, to reduce the tendency to slip. Soft wood blocks, especially those creosoted, have a rather slimy surface, making them probably more slippery when wet than harder blocks having a surface unaffected by moisture. It is an advantage that wood pavements may be sprinkled and slipping thereby reduced. Asphalt, more slippery than wood in the start, cannot be so sprinkled without injury to its surface. It is an axiom in all pavement construction that the coefficient of wear of the component parts of the wearing surface of a pavement should be as nearly constant as possible; in other words, unless the pavement wears evenly in all parts of its surface, it must soon wear out. A pavement of alternate strips of steel bars and asphalt would have practically no life at all; yet a pavement composed of either material alone would give good results. The reason, of course, is that the softer material wears more quickly, producing a rut, which allows heavy loads to fall a short distance, causing a pounding wear much more severe than any possible rolling traffic. For this reason the writer believes that large joints, in any form of pavement, are very undesirable, and several years' experience in the use of vitrified paving brick has resulted in a conviction that the lugs commonly

used on such brick are a mistake, and that better results can be secured with wire-cut brick, laid as close together as possible. In the same way wooden blocks should be laid with the smallest possible joints.

It has been claimed, against the use of wooden blocks—particularly when untreated—that some of the blocks are softer than others and more porous, and consequently will wear more quickly; but this is remedied by the treatment of the block, especially where the mixture of creosote and rosin, called the creo-resinate process, is adopted, owing to the fact that the softer and more porous blocks take up just that much more of the preservative and hardening mixture, and are therefore all brought to the same degree of resistance. At the same time, where only heart wood is used, with no sap whatever, the difference in density of the wood is very small.

The extracts from the specifications of the city of Boston, given in Mr. Wheeler's paper, show the methods employed and the extreme care taken to secure as nearly as possible an absolutely perfect form of construction. These pavements are guaranteed for ten years.

Earlier in this paper the writer has referred to what he considers the ideal wooden pavement. In his opinion this should be about as follows: The concrete foundation—preferably although not necessarily of Portland cement—need not be included, as that or its equivalent is a necessity for all permanent pavements. Suffice it to say that its thickness should be in keeping with the traffic over the street and the nature of the sub-grade.

The blocks forming the wearing surface should be four inches deep on heavily travelled streets and three inches deep on streets of moderate or light travel. This provides a wearing surface considerably deeper than that secured with sheet asphalt, and the wearing qualities of the pavement are greater.

In constructing a perfect wooden pavement, two methods of treating the surface of the concrete may be adopted. It

may either be covered with a very thin cushion of clean fine sand, not exceeding one inch in thickness, and thinner if the upper surface of the concrete will admit of it, or it may be floated with a grout of Portland cement and fine sand, mixed thick and brought to a true surface and grade by the use of a template as in the case of a sand cushion. If the latter method is used, the blocks may either be set in the wet surface of the grout, and lightly tamped or rolled, or the grout may be allowed to harden and its surface slushed with a coating of pitch or asphaltic cement, such as is often used in grouting joints with brick or granite block. Into this coating, while hot, the blocks should be set, and tamped or lightly rolled, as before. The blocks should be set as closely together as possible, both in the direction of the street and from curb to curb, and rammed tight every few courses. By laying the courses at an angle to the curb line, say thirty degrees, better results will be secured, as there is much less chance for the calks of horses' shoes to round off the edges of the blocks. After being laid the joints should be partially filled with very fine clean sand, and the pavement rolled. A much heavier roller may be used with advantage where a sand cushion is used. The Boston pavements above referred to were mostly rolled with a fifteen-ton roller, and no damage whatever was done to the blocks. With brick this would not have been the case. After rolling the joints should be fully filled with sand only, or if desired good asphaltic cement, composed about as follows, and used at a temperature of 300 degrees F. Twenty parts refined asphalt, three parts residuum oil and one hundred parts coal tar, generally known at the works as No. 4. Such a grout should be poured over the entire surface of the street and swept into the joints with a wire broom. A suitable tank, holding ten or twelve barrels, should be used for heating the mixture, and the material may best be dipped out with coal hods or iron buckets. Such a grout adheres much better to the surface of wooden blocks than it does to brick or stone. The creo-resinate mixture itself may also be used for grouting the joints.



LE COUNT PLACE, NEW ROCHELLE, N. Y. LAID WITH CREO-RESINATE WOOD BLOCKS IN 1901.

The surface of the street after grouting should be spread with a coating of fine sharp sand, making a practically perfect roadway.

As regards the character of the wood to be laid, much may be said. Softer pines, comparable to the deals used abroad, creosoted, will make a good and durable pavement, and the company manufacturing the creo-resinate block also manufacture ordinary creosoted block. But for the maximum of durability not exceeded, if indeed equalled by granite block, the heart long leaf Georgia pine is the wood of all others. The experiments on Kings Road in London, and the experience of Paris, as shown above in the relative wear of different woods, places this wood, called abroad pitch pine, next to the Australian hard woods in durability and resistance to abrasion. Such wood may be thoroughly creosoted, and under these conditions will not rot. But two points must be considered. Creosoting alone has a tendency to soften the fibre of wood, and its surface becomes spongy. It also, while not soluble in water, may be washed out by the action of water, and some of its constituent parts being volatile, may evaporate. The problem is therefore to retain the creosote oil absolutely in the wood, and to so harden the fibres of the wood and fill up its pores that it may become both waterproof, and at the same time have an even greater resistance to wear. This may be successfully done by incorporating with the creosote oil used about 50 per cent. of melted rosin—the two forming a perfect mixture when hot, and forcing this compound into the timber under pressure until from 20 to 22 pounds per cubic foot has been driven in. Timber so treated weighs about 5,500 lbs. per thousand feet board measure. Untreated pine of the same quality weighs 4,500 lbs., Swedish deal as used abroad 3,600 lbs. It is, therefore, not difficult to see wherein the additional resistance to abrasion is secured. Such blocks are treated throughout their entire mass, and are absolutely incapable of decay. They are called creo-resinate blocks by the company



SAMPLE SECTION OF CREO-RESINATE WOOD BLOCKS ON HOLLIDAY STREET, BALTIMORE, MD.

manufacturing them, the United States Wood Preserving Company of New York City. There are other steps in the process adopted by this company which need not be mentioned here,—as for instance the complete sterilization of the timber by bringing all its parts up to a temperature of 212 degrees, thereby destroying all germ life in the heart of the wood. The result is that the wood is rendered decay-proof, water-proof and almost wear-proof.

It is argued by some—and no other argument of any importance has been advanced against this form of pavement, that the fact that the wood is so much harder and more durable than the woods used in London, carries with it the disadvantage that the pavement is thereby rendered more slippery. This might be true, were it not for the presence of the high percentage of rosin in and upon the blocks. This material becomes hard without becoming brittle, and retains its elasticity without becoming soft. The rosin produces a clinging surface upon the block—everyone knows that rosin is constantly used in a wide variety of ways to produce friction and prevent slipping, and this is its effect on the street. This pavement is much less slippery than wood treated with creosote oil alone, and in wet weather does not present a soft, slimy and slippery surface.

In the first piece of pavement laid in Boston, that on Tremont street, under the continued action of the sun in very hot weather (there are no buildings on the side of Tremont street next the Common and hence the pavement has no shade from noon until sunset) some of the creosote-resinate material exuded from the joints, and was spread on the surface of the blocks. The pavement was consequently treated with a solution of lime and water, which hardened and solidified the rosin and prevented further trouble on this score. Subsequent streets laid were grouted with paving pitch, creosote-resinate mixture, or as on Boylston street, cement grout, and this trouble has not again presented itself.

The section of pavement on Tremont street, laid in competition with asphalt (the latter paving occupying the east half of the street) is on the right hand, down hill side of the street, the asphalt being on the up hill side. Horses going down hill on the wood have not slipped or fallen more, if as much, as those coming up hill on the asphalt. Of course, all smooth pavements are to some extent slippery—the combination of smoothness, durability and absolute lack of slipperiness is an impossibility; but wood is, in the writer's opinion, the least slippery of all smooth permanent pavements.

The question of expansion joints is one which apparently has been given no attention in the above specifications. As a matter of fact, wood is such a poor conductor of heat that expansion to any extent does not occur from this cause. If the wood absorbed moisture, it might swell or be affected by the frost, but being practically water-proof, it is not so affected. Hence the lack of necessity for expansion joints. This has been proven during the past severe winter and summer by the sections of pavement on Tremont street.

The writer has attempted to show that if woods of moderately good quality wear ten or twelve years under the enormous traffic abroad, harder, better, more durable and more effectually treated woods should show a much longer life under equal traffic, and a still longer life under the comparatively light traffic of cities in this country. With all the experience of Europe back of us, it is not logically necessary that municipal authorities should approach the subject with misgivings, and consider the question of laying small samples and waiting ten years to see if the pavement will wear. The municipal engineers of this country, with full information of what is being done abroad to produce smooth, easy, noiseless and durable streets, need hardly regard the laying of well selected wooden paving blocks, treated in the most thorough manner possible, and properly laid, as an experiment.

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